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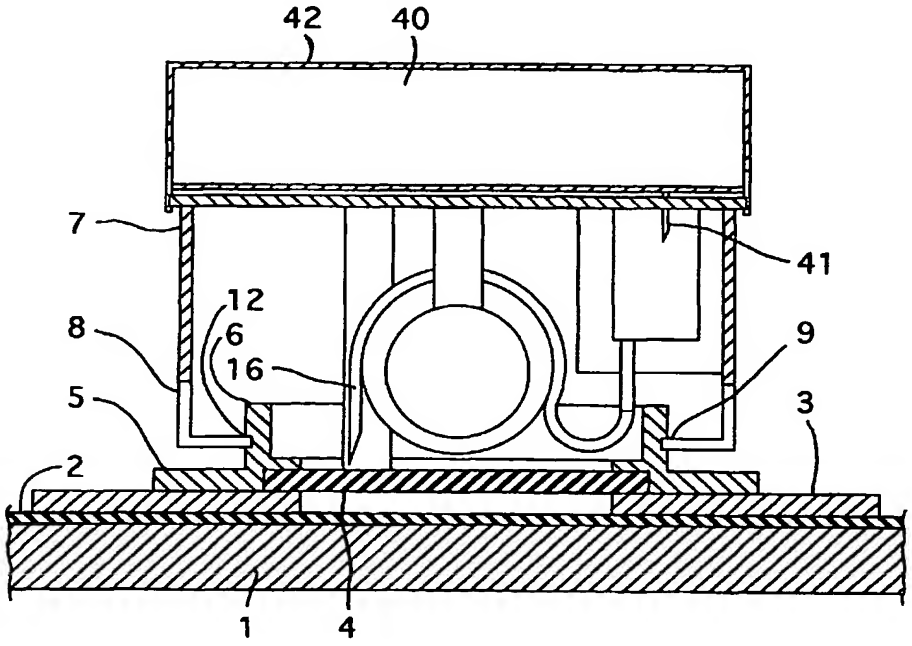
(54) Title: METHOD AND APPARATUS FOR MICRO-SAMPLING



(57) Abstract: A micro-sized device attached to the earlobe of a patient, for periodic, repeated analyses of blood or for injection of medicine. The device comprises a motor for moving a needle into the skin portion of the patient and withdrawal of a minute amount of blood for analysis. The result of the analysis controls the supply of a medical agent through the needle, whereupon the needle is retracted. The device is rotated over an angle before the next sampling, so that the new sampling takes place at a untouched skin area.

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METHOD AND APPARATUS FOR MICRO- SAMPLING

AREA OF INVENTION

The present invention relates to the filed of micro-sampling of body fluids, especially blood, from a mammal, such as a human being.

BACKGROUND ART

The treatment of deceases in ambulant care, requires a number of physiological, heamatological and biochemical analyses at different time intervals. This is especially true for patients with heart, lung and kidney diseases as well as endocrine deceases such as diabetes. These diseases are on the increase, especially in the aging population of the Western world.

The object of this invention is to facilitate making these analyses and providing medical agents. When punctuating the skin several times, it is desired to do the punctuation at different positions, so that a new skin portion is always used. Moreover, it is important that the needle is always sterile.

Another object of the invention is to provide a sample device, which is so small that it can be carried at the skin without preventing normal behavior of the patient.

A further object of the invention is to provide a sample device, which communicates wirelessly with a control computer and/or a central computer.

SUMMARY OF INVENTION

Thus, there is provided a device for repeated sampling through the skin of a patient, comprising a means for attaching the device to a skin portion; a sterilization membrane positioned immediately above the skin portion when the device is positioned at the skin portion; a punctuation needle moveable between a first position in which the needle is positioned immediately above the membrane and a second position where the needle extends through the membrane and into the adjacent skin portion; and a repositioning means for, when the needle is in its position above the membrane, moving the needle so that it, during the next punctuation of the skin portion punctuates it at a position displaced from the first position. The needle may be arranged at a rotateable wheel, which is adapted to move the needle by means of a motor for automatic punctuating the skin portion. The device may be attached to the skin portion by means of a plaster provided with a central recess. The plaster may be a ring, and the device may be circular symmetrical and the needle may be adapted to be rotated inside the plaster. In order to perform the rotation, the device may comprises a circular gear ring extending along the periphery and being attached to the plaster. A motor with a gear wheel engages the gear ring, so that at activation of the motor, the device is rotated in relation

to the plaster, over for example 22,5 degrees. The needle may be connected to a transparent hose, through which a light source transmits light which passes through the hose to be analyzed by an optical analysis unit positioned at the other side of the hose. Moreover, a peristaltic pump is arranged for moving the fluid.

The device may be used for analysis of blood data, such as the contents of oxygen or carbon dioxide in the blood.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects, features and advantages of the invention will appear from the following detailed description of several embodiments of the invention with reference to the drawings, in which:

Fig. 1 is a plan view of the apparatus with a cover removed.

Fig. 2 is a cross-sectional view of the apparatus according to Fig. 1 taken along lines II-II in Fig. 1.

Fig. 3 is a cross-sectional view of the apparatus according to Fig. 1 taken along lines III-III in Fig. 1.

Fig. 4 is a cross-sectional view of the apparatus according to Fig. 1 taken along lines IV-IV in Fig. 1.

Fig. 5 is a cross-sectional view of the apparatus similar to Fig. 2 but in an enlarged scale.

Fig. 6 is a plan view of a sterilizing filter in the apparatus of Fig. 1.

Fig. 7 is a cross-sectional view of the filter of Fig. 6 taken along lines VII-VII in Fig. 6.

Fig. 8 is a schematic view of the operation of the apparatus of Fig. 1.

Fig. 9 is a schematic view of the interconnections of the apparatus of Fig. 1 with a central computer.

Fig. 10 is a plan view of a second embodiment of the invention, with a cover removed.

Fig. 11 is a magnified cross-sectional view of a second embodiment of the invention, taken along line XI-XI of Fig. 10.

Fig. 12 is a magnified cross-sectional view of a second embodiment of the invention, taken along line XII-XII of Fig. 10.

Fig. 13 is a plan view of a plaster and a sterilizing filter in the second embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

The apparatus according to the invention is shown in Fig. 1, with a cover removed. With reference to Figs. 1 to 4, the apparatus is attached to a blood vessel rich body portion 1, such as the backside of an earlobe, having a skin area 2, see Fig. 2. The apparatus comprises a rectangular plaster 3 attached to a base 5 of the apparatus. The plaster has a sticky surface,

which attaches to the skin area 2. Moreover, the plaster has a circular recess covered by a sterilizing filter 4. The plaster may have another shape, such as circular, ring-shaped, or oval.

The upper side of the base 5 comprises a ring gear 6. The apparatus has a cover 7 providing mounting braces for the parts of the apparatus. The cover is provided with several slits 8 which are bent inwardly as shown at 9 in Fig. 2 to engage a peripheral slit 12 in the wall of the ring gear. In this way, the cover may rotate in relation to the ring gear 6.

A micro-motor 13 is attached to the cover and comprises a gear box with a gear wheel 14 for engagement with the gear ring 6, as is clearly shown in Fig. 4. Thus, the cover may be rotated in relation to the gear ring, the sterilizing filter and the plaster under control of the motor 13. The motor 13 may be a step motor, driven by suitable electronics known per se.

A micro needle, electrode or canula is controlled by a second micro motor 15 provided with a gear box, as is shown more clearly in the enlarged Fig. 5, and as further described below.

The sterilizing filter 4 is shown in further details in Figs. 6 and 7. The filter comprises two elastic membranes 11 enclosing a sterilizing agent 10, preferably in gel form. The sterilizing filter is inserted between the base 5 and the plaster 3 as clearly appears from Fig. 5.

As appears from the schematic view of Fig. 8, the needle is guided by a guide sleeve 28 in the vertical direction as seen in Figs. 5 and 8. The needle is preferably made by stainless steal and is terminated by a sharp tip, so that the needle may pass the elastic membranes of the filter without cutting out pieces of the membrane, as is well known. The needle is attached to a transparent hose 17 which is attached to a wheel 18 by means of a transparent fastener 19. The wheel is controlled by the motor 15.

A light source 20 directs light towards the transparent fastener 19 and the transparent hose 17 positioned therein. After passing the fastener and hose, the light is collected by an analysis apparatus 21, which analysis the contents of the hose. The resultant electric signal is transmitted via a wire 22 to an electronic unit.

Furthermore, the transparent hose 17 is attached to a plastic hose 23, which is influenced upon by a peristaltic pump as shown in Fig. 8. Finally, the plastic hose 23 terminates in a plastic container comprising a medical agent. The pump 24 is controlled by motor 15 as explained below. The transparent hose and the plastic hose may be the same hose and be made in one piece.

The operation of the apparatus of the invention is as follows. The wheel 18 may be rotated by the motor 15 over about 45 degrees to the position shown in Fig. 8, during which the needle is moved from a retracted position inside the sleeve 28, and through the filter 4 to contact and puncture the skin 2 and enter the blood vessel rich skin portion 1. The needle may be retracted by rotating the wheel 18 clockwise over 45 degrees, as explained below.

In the position shown in Fig. 8, the needle tip is in contact with body fluids, such as blood inside the skin portion. The motor 15 is now switched to operate the peristaltic pump

24, while wheel 18 is left in its position as shown, locked by a locking mechanism, not shown. Pump 24 is operated clockwise to suck blood into the needle 16 and the transparent hose 17. The light source 20 is switched on and the light passing the blood in the transparent hose is analyzed in the analysis unit 21 to obtain blood parameters.

After analyzing the blood parameters, a control circuit 26 determines an amount of medical agent to be transferred to the blood. Then, the pump 24 is operated in the counterclockwise direction to return the fluid inside the hose to the skin area and to further pump the medical agent into the skin area and a blood vessel therein. Thus, the analyzing circuit determines how many revolutions the pump should be operated, whereupon it is stopped. Then, the motor is again connected to wheel 18 in order to rotate the wheel 45 degrees in the clockwise direction to retract the needle. Finally, the first motor is operated to rotate the cover in relation to the base over a predetermined angle, such as 22,5 degrees. Then, the apparatus is ready for a new cycle, in which the needle will puncture an new area of the skin. After 16 cycles, the apparatus is again in its initial position.

A rechargeable battery 27 provides electric power to the apparatus.

One application area for the present invention is to analyze blood sugar level and inject insulin, for diabetes patients. Other application areas may include only sampling of the blood or other body fluid without injecting a medical agent, such as analysis of urea level for a dialysis patient.

In Fig. 9 there is schematically shown the apparatus according to the invention attached to a patient. The apparatus 31 is attached to the earlobe of the patient and communicates with a relay unit 32 via wires, or via a wireless connection, such as a short-range radio transmission, such as Bluetooth. The relay unit is attached to the patient in a convenient place, such as at the ankle or in a pocket, and may comprise a powerful battery. The apparatus 31 may be powered via wires from the relay unit 32. In another alternative, the apparatus 31 includes a small battery and a radio transmission to the relay unit, having low power consumption.

The relay unit 32 and the apparatus 31 communicates with an evaluating, transmitting, instruction-receiving unit 33, which may be a portable computer (PC) or a small handheld computer, such as a PDA. Again the communication may take place by wires or by short-range radio transmission, such as Bluetooth, or longer distance communication.

The unit 33 may further be connected to a central computer 34, such as a hospital computerized system, for example via modem connection or Internet. The connection between unit 33 and the central computer 34 may take place at specified time intervals, such as once per day, in order to transmit the analysis data to the central computer for storage and overview by a doctor. The connection between unit 33 and the central computer 34 may also take place wirelessly, for example via a mobile telephone operating as a modem. Alternatively, the unit 33 may be transported to the central computer 34 and connected thereto, for example via USB

connection of serial connection.

The relay unit 32 may have certain computing capacity, for example for feed-back control of medical agent supply. The unit 33 may have further capacity, such as large storage capability. It is realized that the units 32 and 33 may be combined to a single device in certain applications.

The setup may include further sensors, such as an external oxygen sensor 35a, which measures the oxygenisation level of the blood, and a carbon dioxide sensor 35b which measures the carbon dioxide level in the air expelled from the lungs of the patient. These sensors may aid in the control of the oxygen supply from an oxygen source 36 via a control valve 35 for a patient with reduced lung capacity.

The purpose of the sterilizing filter is to keep the needle sterile and to clean the needle from particles that may have become attached to the needle. To ensure this, the sterilization filter membranes 11 are made from an elastic material that embraces the needle as it passes through the membrane.

The apparatus according to the invention may as well be attached to another skin area, such as the inside of the ankle, with arterial punctuation with extremely thin punctuation means for blood gas analysis. The selection of punctuation area takes place by moving the needle to the area having the largest pressure response (pulse) by using a built in pressure sensor of known type in the same apparatus, thereby giving less blood leakage risk after the retraction of the needle.

Other applications are feedback programming of the punctuation means to a renewed punctuation operation if the analysis signals of the first analysis indicates compromised signal results.

Above, it is stated that the cover is rotated over 22, 5 degrees so that there are 16 distinct positions. The rotation may as well be over 23 degrees, so that the 17:th punctuation area is displaced from the first punctuation area by 8 degrees.

In Fig. 8 it is shown that the peristaltic pump 24 is separate from the wheel 18. However, in the apparatus shown in Fig. 5, the peristaltic pump is concentric with the wheel 18 and positioned offset along the shaft of the motor 15. Thus, the motor 15 may be connected to the wheel 18 in order to rotate the wheel for insertion and removal of the needle, and then be disconnected from the wheel and connected to the pump for operation of the pump. The transparent hose is first winded a turn around wheel 18 and then another turn around the peristaltic pump stator positioned there behind.

In Fig. 5, there is shown a removable medical agent supply 40 connected to cover 7 by a second cover 42. The supply 40 comprises a needle 41, which passes into container 25.

Before use of the apparatus according to Fig. 1, it is primed by rotating the peristaltic pump 24 in the counterclockwise direction in order to expel air inside the hoses and the needle and replace the air by the contents of the container 25, which may be physiological saline

solution or a medical agent. Thus, any air inside the system is removed. Moreover, the analysis unit 21 may be calibrated when the known solution from the container is present inside the hose 17.

The size or diameter of the needle may be 20 to 100 micrometer, which means that the punctuation of the skin is practically painless.

Figs. 10, 11 and 12 discloses a second embodiment of the apparatus of the invention. The apparatus comprises two needle units as appears from Fig. 12. Each needle unit is driven by the motor 65 by means of operating different clutches. Moreover, each needle is positioned in a sleeve, whereby the sleeve is moveable through the sterilizing filter, whereupon the needle is moveable out of the sleeve into the skin. In other respects, the second embodiment operates as described in connection with the first embodiment.

Fig. 13 discloses the sterilization filter in the second embodiment, which is divided in 8 regions. The plaster is provided with vulced areas for the attachment of the base of the apparatus according to the invention.

The dual needle assembly may be used for increased safety that the needle reaches a skin area comprising blood vessels. Another use is the continuous supply of medical agent through the second needle in dependence of blood sample measurement in the first needle. A third use is the micro-dialysis of blood removed from an artery or vein below the apparatus, whereby blood is circulated into the first needle and into the apparatus and back to the blood via the second needle.

The device according to the invention may be used in different applications, such as:
1) separate sampling, for collecting data, for example blood parameters, such as glucose concentration, hematocrite, oxygen content, carbon dioxide content, pH etc.
2) feed-back and injection of medical agent in dependence of sample analysis, such as insulin
3) sending out an alarm if certain conditions are fulfilled
4) control of external supply of agents, such as oxygen gas to the patient, based on sample analysis
5) combined with other sensors, such as carbon dioxide contents of the exhausted air from the lungs.

The invention has been described hereinabove by means of several embodiments of the invention. However, the different features may be combined in different manners without departing from the scope of the invention. The invention is only limited by the appended patent claims.

PATENT CLAIMS

1. A device for repeated sampling through the skin of a patient, **characterized** by

a means for attaching the device to a skin portion;

a punctuation needle moveable between a first position in which the needle is positioned immediately above the skin portion and a second position where the needle extends into the adjacent skin portion; and

a repositioning means for, when the needle is in its position above the skin portion, moving the needle so that it, during the next punctuation of the skin portion, punctuates the skin portion at a second position displaced from the first position.

2. Device as claimed in claim 1, **characterized** by a sterilization membrane positioned immediately above the skin portion when the device is positioned at the skin; and in which the means for attaching the device at a skin portion comprises a plaster provided with a central recess in which said membrane is arranged.

3. Device as claimed in claim 1 or 2, **characterized** in that the punctuation needle is arranged at a rotateable wheel, which is adapted to move the needle by means of a motor for punctuating the skin portion.

4. Device as claimed in claim 1, 2 or 3, **characterized** in that the plaster is ring-shaped, and in that the device is circular symmetrical and in that the needle is adapted to be rotated inside the plaster.

5. Device as claimed in claim 4, **characterized** in that the device comprises a circular gear ring extending along the periphery and being attached to the plaster and in that a motor with a gear wheel engages the gear ring, so that at activation of the motor, the device is rotated in relation to the plaster, over for example 22,5 degrees.

6. Device as claimed in any of the preceding claims, **characterized** in that the needle is connected to a transparent hose, through which a light source transmits light which passes through the hose to be analyzed by an optical analysis unit positioned at the other side of the hose.

7. Device according to claim 6, **characterized** in that the needle is connected to a hose, comprising a transparent portion for the analysis unit and an elastic portion for cooperation with a peristaltic pump, said hose extending to a container for a medical agent.

8. Device according to any of the preceding claims, **characterized** in that it is intended to be used for analysis of blood data, such as the contents of glucose, oxygen or carbon dioxide in the blood.

9. Method of using a device as claimed in claim 7, **characterized** in that the device is applied at a skin portion, a needle is adapted to punctuate a membrane and a skin portion, in that a pump is activated for the removal of a fluid, such as blood into the needle and to a transparent portion, in that the fluid is analyzed by an analysis unit, and in that an amount of a medical agent is pumped via the needle into the skin portion.

10. Method as claimed in claim 9, **characterized** in that the device communicates with a relay and analysis device, preferably carried at the body, and communicating with an adjacent computer, which in turn is in communication with a central computer.

Fig. 2

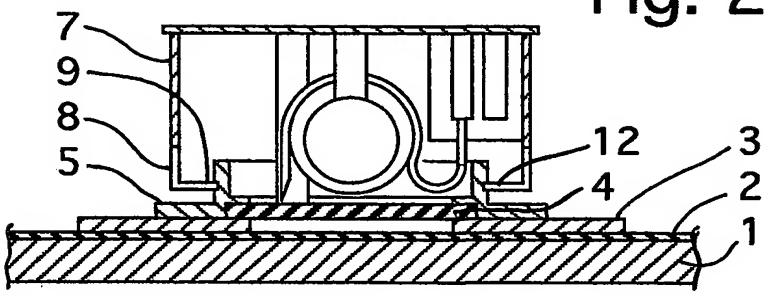
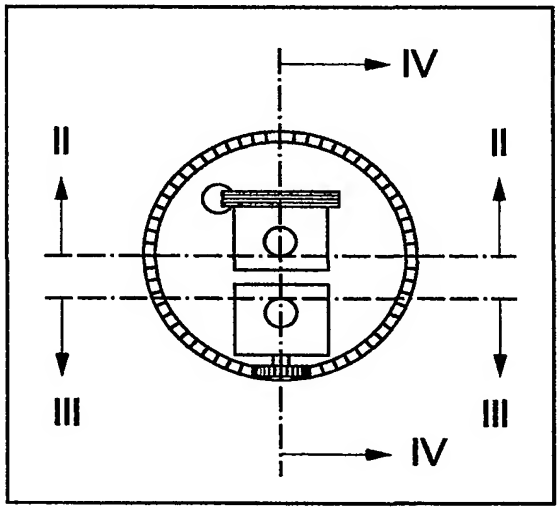


Fig. 1



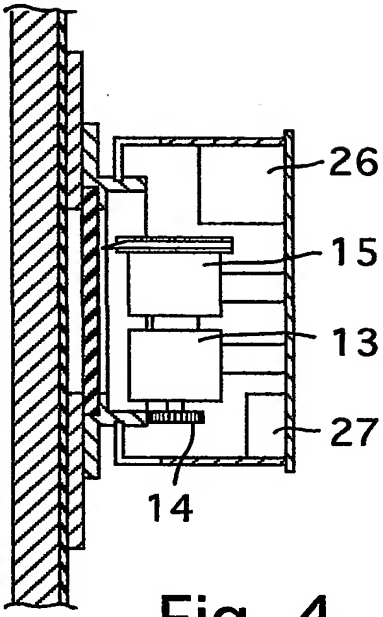


Fig. 4

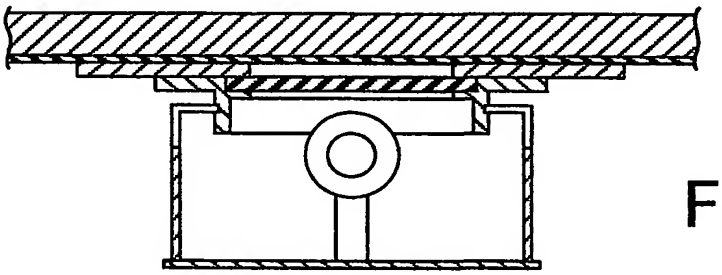


Fig. 3

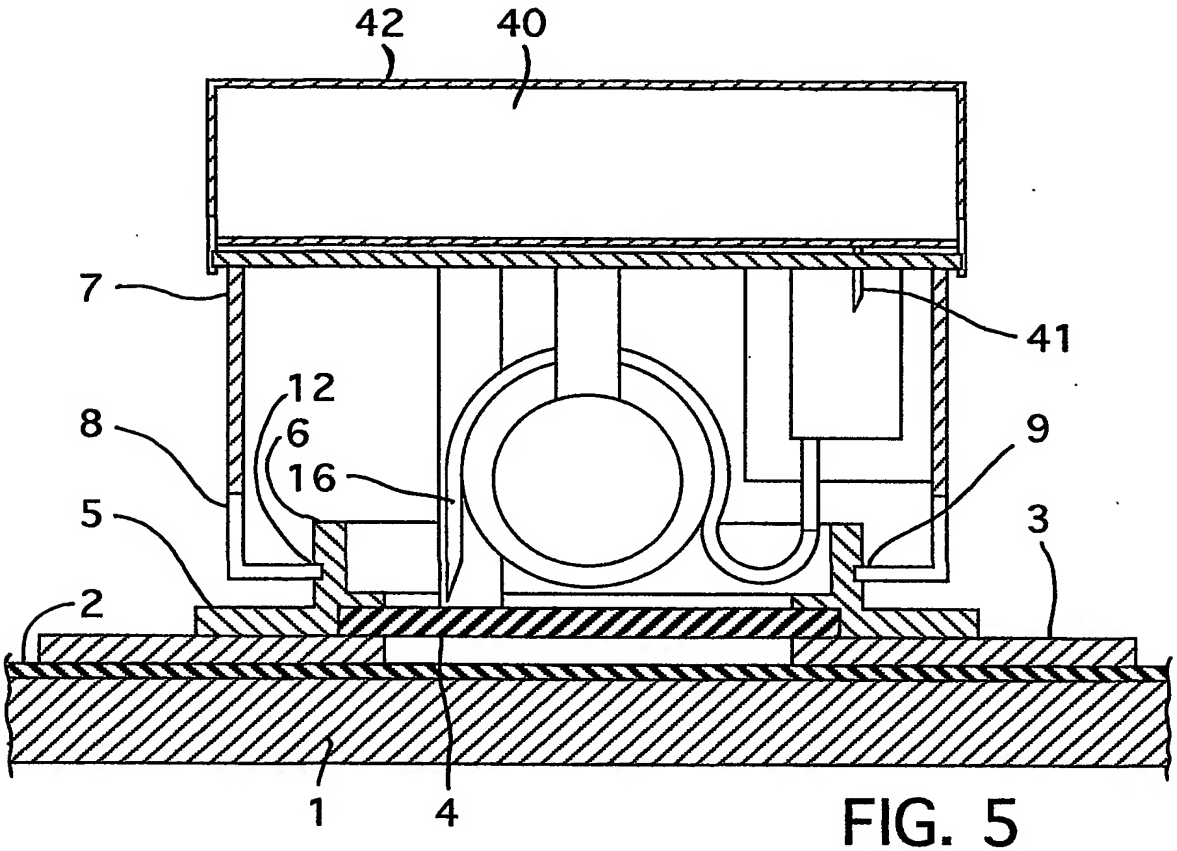


FIG. 5

FIG. 7

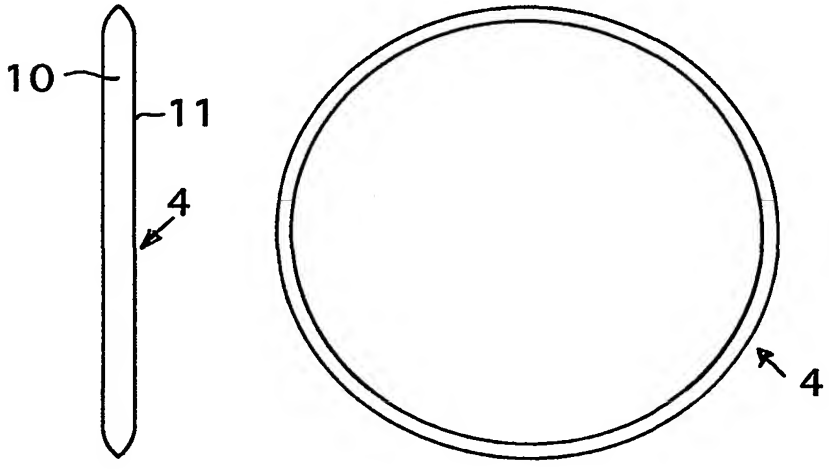


FIG. 6

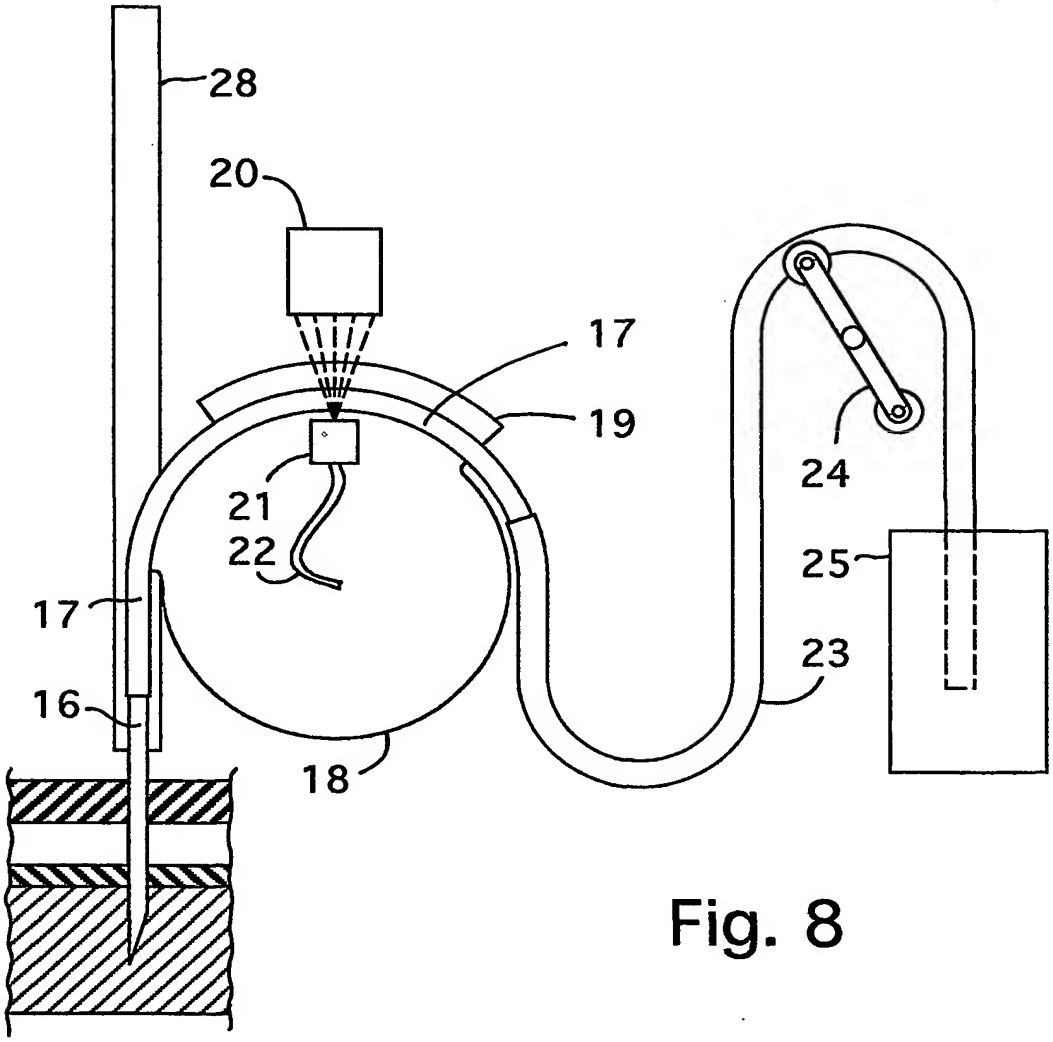


Fig. 8

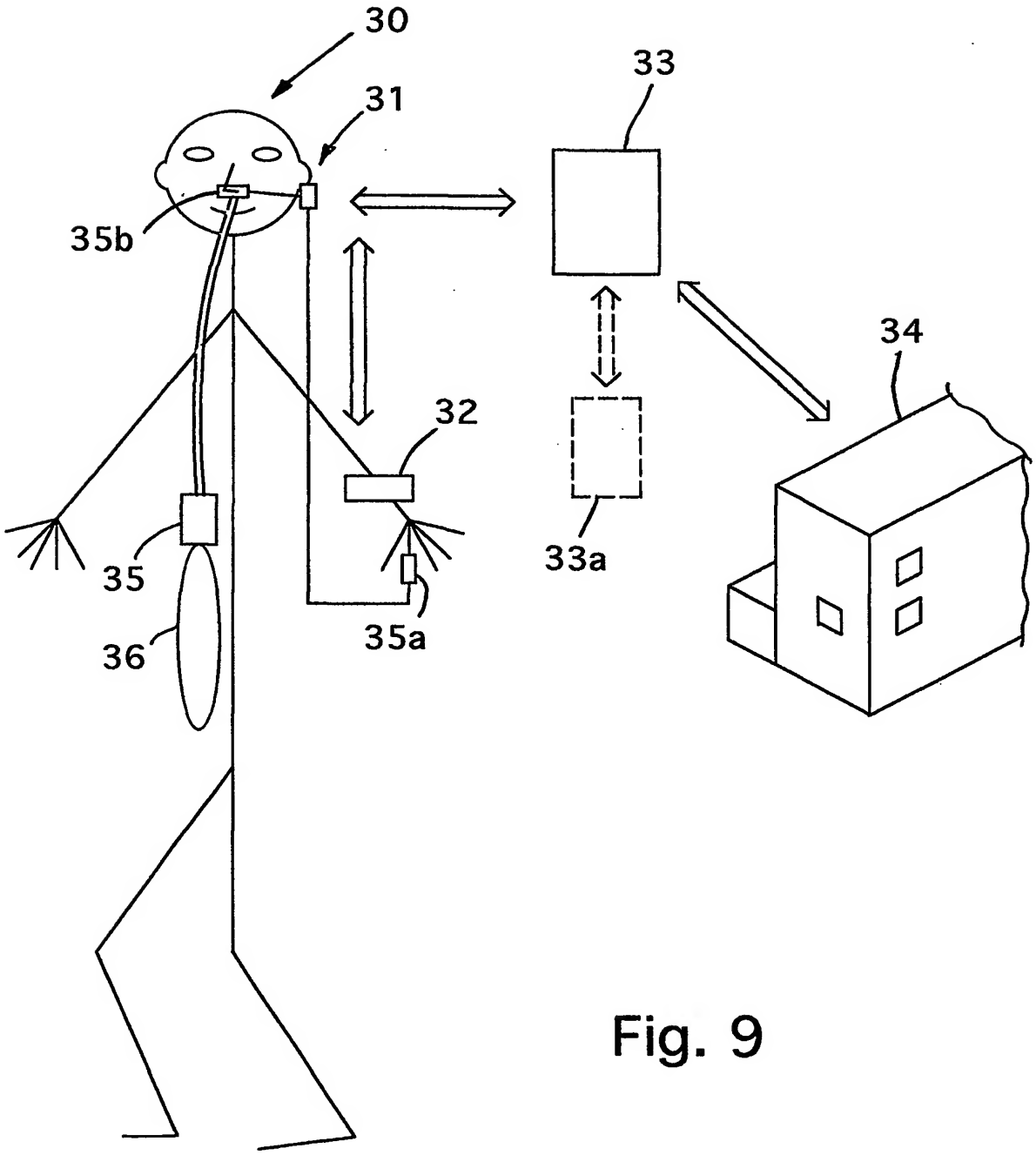


Fig. 9

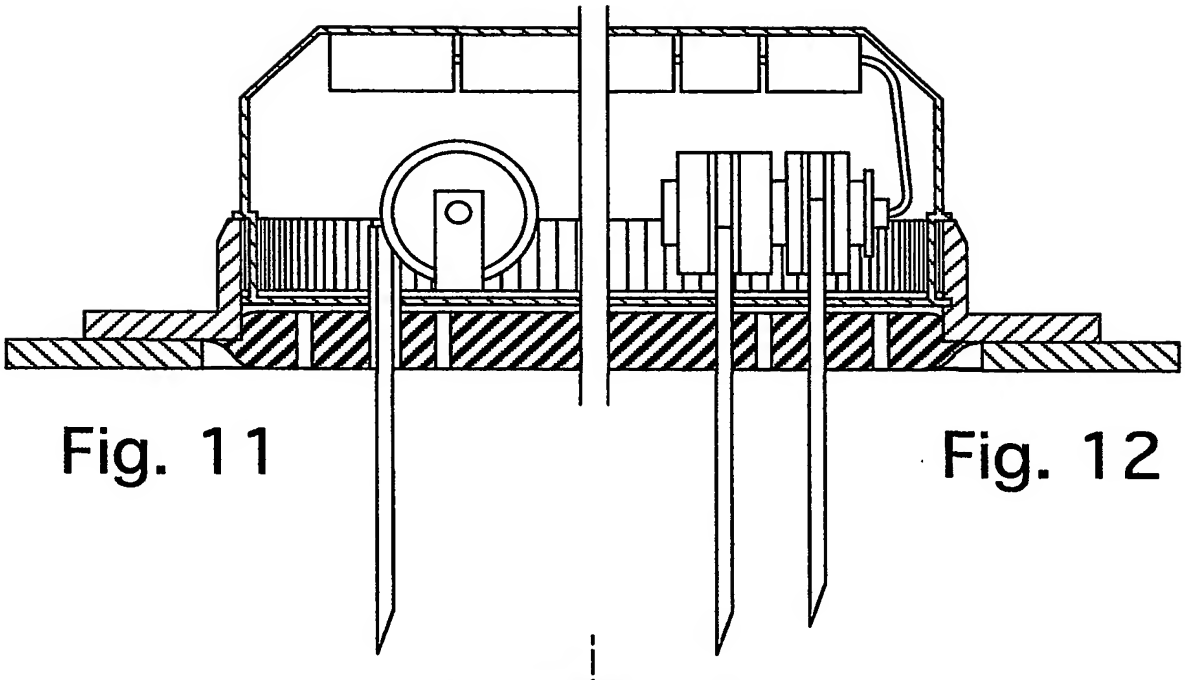
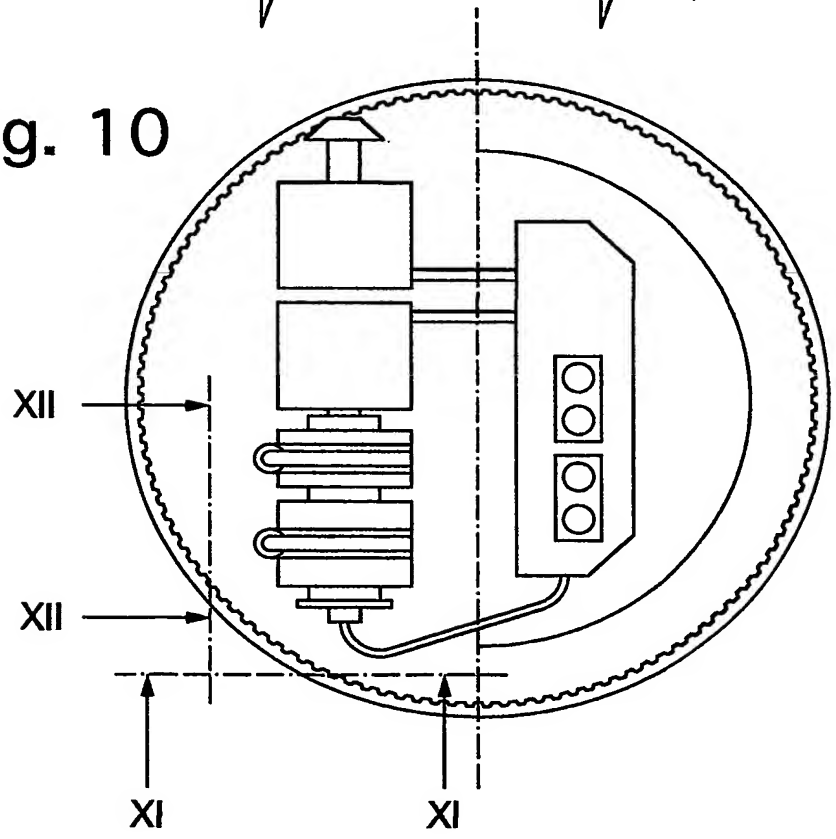


Fig. 11

Fig. 12

Fig. 10



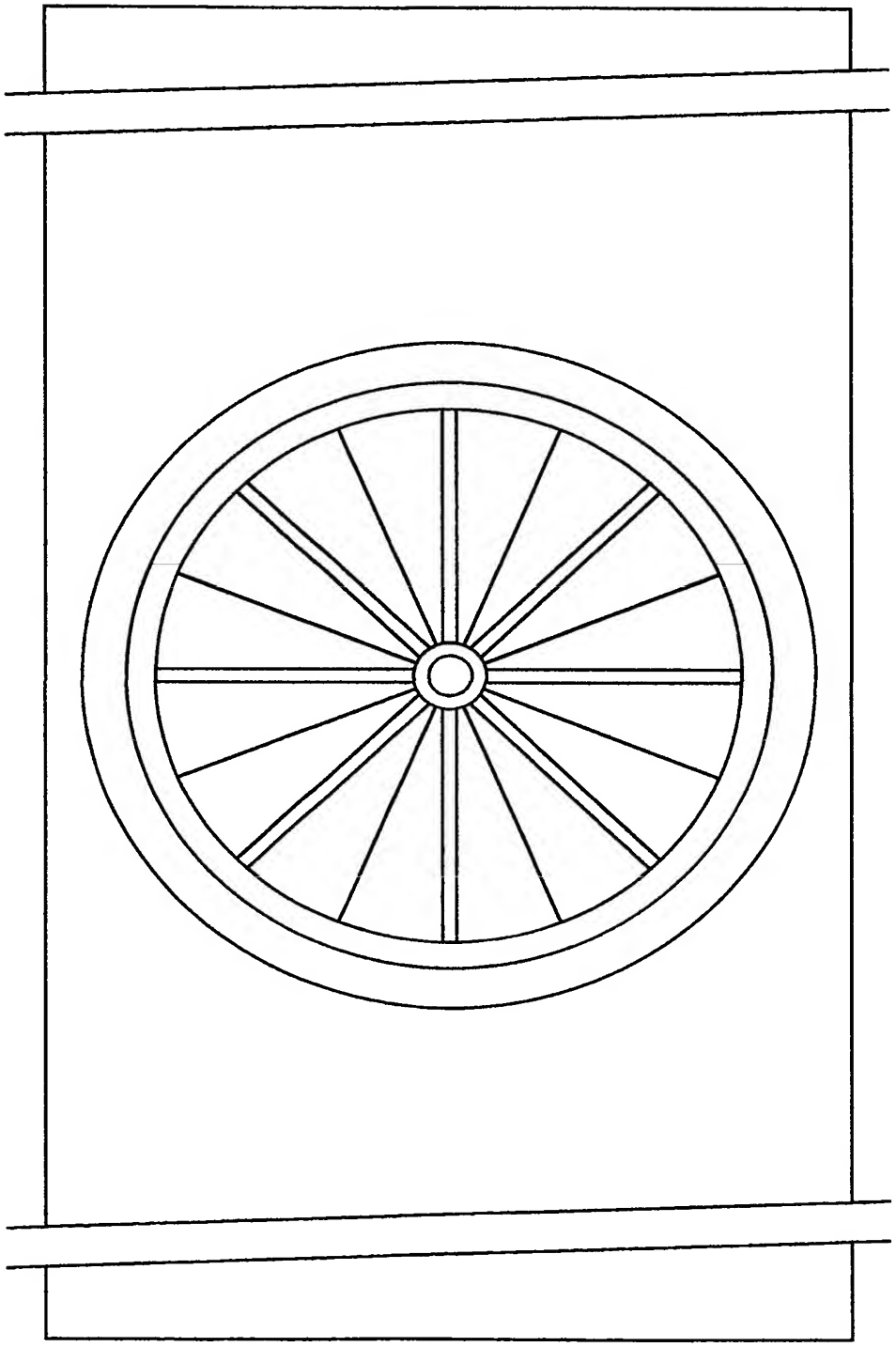


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00156

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A61B 5/155
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, INSPEC, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5759160 A (J. NEESE ET AL.), 2 June 1998 (02.06.98), figure 1, abstract ---	1-10
A	US 5785662 A (G.E. ALEXANDER), 28 July 1998 (28.07.98), figure 1, abstract --- --------	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 June 2002	06 -06- 2002
Name and mailing address of the ISA: Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Patrik Blidefalk/AE Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/05/02

International application No.
PCT/SE 02/00156

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5759160 A	02/06/98	AU 1078897 A	11/06/97
		US 6159164 A	12/12/00
		WO 9718748 A	29/05/97
US 5785662 A	28/07/98	AU 3147797 A	05/01/98
		WO 9745055 A	04/12/97